Description

Improvements in or relating to multipanel sliding doors

Technical Field

The present invention relates to multipanel sliding doors, such as those used for providing a controlled access to an entranceway or the like in a wall or similar building structure.

Background Art

Multipanel sliding doors of the kind mentioned above generally comprise two or more panels which are supported for travel in substantially parallel planes along runners. In a known arrangement, the door panels are caused to move in a stepwise manner, i.e. the door panels are interconnected to each other in such a way that, in closing the door, a first panel is caused to move in one direction and, once it has covered a certain distance, said first panel engages a second panel and pulls it along in its movement. The second panel, in turn, after having covered a certain distance, engages a third panel, and so on until all the panels of the door are drawn out to the full extension. In opening the door, the panels are moved in the same sequence as described above, but in an opposite direction.

An arrangement of this kind has at least two significant disadvantages in operation. The first is concerned with the noise produced by the knocking of a moving panel against a stationary panel, when the former is moved into engagement with the latter.

A second disadvantage is that opening and closing of the door is achieved through a number of steps each requiring a pulling or pushing effort which increases with the number of panels which are operated.

Disclosure of Invention

The present invention is directed to an improvement to a multipanel sliding door of the kind mentioned above so that said disadvantages are avoided and the operation of the door panels is synchronised.

The invention achieves this object by providing a multipanel sliding door comprising at least two panels which are supported for travel in substantially parallel planes along runners, characterised in that a rack and wheelwork arrangement is provided for the movement of the door panels.

Brief Description of Drawings

The invention will now be elucidated in connection with the figures of the accompanying drawings, wherein:

Fig. 1 is a perspective partial view of a first preferred embodiment of the multipanel sliding door according to the present invention;

Fig. 2 is a side partial view of the multipanel sliding door of Fig. 1;

Fig. 3 is a perspective partial view of a second preferred embodiment of the multipanel sliding door according to the present invention;

Fig. 4 is an exploded perspective partial view of the multipanel sliding door of Fig. 3;

Fig. 5 is a perspective partial view of a third preferred embodiment of the multipanel sliding door according to the present invention; and

Fig. 6 is an exploded perspective partial view of the multipanel sliding door of Fig. 5.

Best Mode for Carrying out the Invention

Referring to Figs. 1 and 2 of the drawings, a first embodiment of the multipanel sliding door is comprised of a door header F extending parallel to a door runner not shown, which may be of any suitable kind known in the art, and a set of adjacent panels P = {P_0, P_1, P_2, P_3, P_4}, whereof a panel P_0 is stationary and the remaining panels P_1-P_4 are supported for travel in planes substantially parallel thereto. Panels P_0-P_4 have preferably equal width L.

For the movement of the panels an arrangement is provided which is comprised of a first set of racks CF = {CF_0, CF_1, CF_2} which are fixedly supported by door header F, a second set of racks CP = {CP_2, CP_3, CP_4} which are attached to or formed unitarily with panels P_2, P_3, P_4, respectively, and a set of wheelworks R = {R_1, R_2, R_3}

which are rotatably mounted on panels P_1, P_2, P_3, respectively, and are designed to mesh together with first CF and second CP set of racks.

The length of racks CF_0, CF_1, CF_2 is equal to L, 2L, 3L, respectively, whereas the length of racks CP_2, CP_3, CP_4 is equal to L.

Set of wheelworks R includes wheelwork R_1 formed of a single toothed wheel which is meshed together with rack CF_0 of set CF and with rack CP_2 of set CP, and wheelworks R_2, R_3 each formed of two coaxial and co-rotating toothed wheels, whereof a first larger diameter toothed wheel is meshed together with rack CF_1, CF_2, respectively, of set CF and a second smaller diameter toothed wheel is meshed together with rack CP_3, CP_4, respectively, of set CP.

The selection of a suitable ratio of the diameters of the toothed wheels forming wheelworks of set R is made under the criterion of providing a kinematical link whereby the displacement of the k-th panel P_k is in any time k times the displacement of panel P_1.

In fact, in a multipanel sliding door as described above, comprising a set of panels P having each a width L, the door shall reach its full extension when panel P_1 has travelled a distance L, panel P_2 a distance 2L, panel P_3 a distance 3L, with respect to fixed panel P_0.

This may be formulated explicitly and generally by the rule that the displacement s_k of the k-th panel P_k is proportional to k, where subscript $k \geq 1$.

For determining in a general way the ratio of the diameters of the toothed wheels forming the k-th wheelwork R_k of set R, one may

note that when panel P_k covers a distance s_k, panel P_{k+1} which is adjacent thereto overtakes the former by a distance which is equal to:

$$s_{k+1} - s_k = \pi\, n_k\, d_k \qquad (1)$$

where n_k is the rotational speed of wheelwork R_k, and d_k is the diameter of the smaller toothed wheel of wheelwork R_k.

The rotational speed of the k-th wheelwork R_k of set R is given by the relationship:

$$n_k = s_k/(\pi\, D_k) \qquad (2)$$

where D_k is the diameter of the larger toothed wheel of wheelwork R_k.

Substituting eq. 2 for n_k in eq. 1 gives:

$$s_{k+1} - s_k = \pi\, s_k\, d_k/D_k \qquad (3)$$

Under the general rule that the displacement s_k of the k-th panel P_k, where subscript $k \geq 1$, is proportional to k, eventually the following relationship is obtained:

$$D_k/d_k = k \qquad (4)$$

Thus, by applying eq. 4 in the case of the multipanel sliding door shown in Figs. 1 and 2, one obtains the following ratios:

Wheelwork R_k	Ratio of wheel diameters D_k/d_k
R_1	$1^{(*)}$
R_2	2
R_3	3

(*) Clearly, this corresponds to having a single wheel of diameter D_1.

By using the above ratios in the design of wheelworks R_k of set R, the displacement s_k of the k-th panel P_k is proportional to k, where subscript $k \geq 1$, and the extension of the multipanel sliding door may range from L to (number of panels +1)×L, L being the width of each panel as mentioned above.

Referring to Figs. 3 and 4 of the drawings, a second embodiment of the multipanel sliding door is comprised of a set of adjacent panels $P = \{P_0, P_1, P_2, P_3, P_4\}$, whereof a panel P_0 is stationary and the remaining panels P_1-P_4 are supported for travel in planes substantially parallel thereto. Panels P_0-P_4 have preferably equal width L. Panels P_0, P_1, P_2 have an extension arm B_0, B_1, B_2, respectively, at their top which extends in the direction of travel of the panels.

For the movement of the panels an arrangement is provided which is comprised of a first set of racks $CS = \{CS_0, CS_1, CS_2\}$ which are attached to or formed unitarily with the extension arms B_0, B_1, B_2 of panels P_0, P_1, P_2, respectively, a second set of racks $CD = \{CD_2, CD_3, CD_4\}$ which are attached to or formed unitarily with panels P_2,

P_3, P_4, respectively, and a set of wheelworks $R = \{R_1, R_2, R_3\}$ which are rotatably mounted on panels P_1, P_2, P_3, respectively, and are designed to mesh together with first CS and second CD set of racks.

Racks CS_0, CS_1, CS_2 are facing towards panels P_1, P_2, P_3, respectively, whereas racks CD_2, CD_3, CD_4 are facing towards panels P_1, P_2, P_3, respectively.

Also in this second embodiment it is desirable that a kinematical link be provided whereby the displacement of the *k*-th panel P_k is in any time *k* times the displacement of panel P_1.

In the second embodiment, one may observe that when panel P_k travels a distance s_k, panel P_{k+1} adjacent thereto overtakes the former by a distance which is equal to:

$$s_{k+1} - s_k = \pi\, n_k D_k \qquad (5)$$

where n_k is the rotational speed of wheelwork R_k, and D_k is the diameter of the toothed wheel of wheelwork R_k.

The rotational speed of the *k*-th wheelwork R_k of set R is given by the relationship:

$$n_k = (s_k - s_{k-1}) / (\pi\, D_k) \qquad (6)$$

Substituting eq. 6 for n_k in eq. 5 gives:

$$s_{k+1} - s_k = s_k - s_{k-1} \qquad (7)$$

and thus:

$$s_{k+1} = 2s_k - s_{k-1} \qquad (8)$$

where subscript $k \geq 1$.

Considering that $s_0 = 0$ because panel P_0 is stationary, from eq. 8 one obtains:

Panel P_{k+1}	Displacement s_{k+1}
P_2	$s_2=2s_1$
P_3	$s_3=2s_2-s_1=3s_1$
P_4	$s_4=2s_3-s_2=4s_1$

Thus, also with the arrangement of the second embodiment the desired kinematical link is obtained, i.e. the displacement of the k-th panel P_k is in any time k times the displacement of panel P_1.

Both first and second embodiments include an end panel P_0 which is stationary and the movement of the remaining panels P_1- P_4 occurs always in a certain given direction with respect to the stationary panel.

This limitation can be overcome with the following third embodiment illustrated in Figs. 5 and 6, wherein all the panels are supported for travel in substantially parallel planes and the multipanel sliding door can be extended in either direction desired, depending on which end panel is kept in a fixed position.

Referring to Figs. 5 and 6 of the drawings, the third embodiment of the multipanel sliding door is comprised of a set of adjacent panels $P = \{P_0, P_1, P_2, P_3, P_4\}$, which are supported for travel in substantially parallel planes and have preferably equal width L.

For the movement of the panels an arrangement is provided which includes a first set of racks $CS = \{CS_0, CS_1, CS_2\}$ which are attached to or formed unitarily with panels P_0, P_1, P_2, a second set of racks $CD = \{CD_2, CD_3, CD_4\}$ which are attached to or formed unitarily with panels P_2, P_3, P_4, respectively, and a set of pairs of wheelworks $R = \{(RS_1, RD_1), (RS_2, RD_2), (RS_3, RD_3)\}$ which are rotatably mounted on panels P_1, P_2, P_3, respectively, and are designed to mesh together with first CS and second CD set of racks.

Racks CS_0, CS_1, CS_2 are facing towards panels P_1, P_2, P_3, respectively, whereas racks CD_2, CD_3, CD_4 are facing towards panels P_1, P_2, P_3, respectively.

Each pair of wheelworks (RS_1, RD_1), (RS_2, RD_2), (RS_3, RD_3) includes a first wheelwork RS_1, RS_2, RS_3 designed to mesh together with rack CD_2, CD_3, CD_4, respectively, of second set of racks CD and a second wheelwork RD_1, RD_2, RD_3 designed to mesh with rack CS_0, CS_1, CS_2, respectively, of first set of racks CS.

The first and second wheelwork of each pair of wheelworks (RS_1, RD_1), (RS_2, RD_2), (RS_3, RD_3) are interlinked with one another by a transmission T_1, T_2, T_3, respectively, in order to rotate at the same rotational speed. In the embodiment shown, transmission T_1, T_2, T_3 is formed of an endless belt.

In order to understand the operation of the third embodiment, one may consider for instance panel P_0 as a stationary panel and the remaining panels P_1-P_4 supported for travel in planes substantially parallel thereto.

Also in this third embodiment it is desirable that a kinematical link be provided whereby the displacement of the k-th panel P_k is in any time k times the displacement of panel P_1.

In the third embodiment, one may observe that when panel P_k travels a distance s_k, panel P_{k+1} adjacent thereto overtakes the former by a distance which is equal to:

$$s_{k+1} - s_k = \pi\, n_k D_k \qquad (9)$$

where n_k is the rotational speed of wheelwork R_k, and D_k is the diameter of the toothed wheel of wheelwork R_k.

The rotational speed of the k-th wheelwork R_k of set R is given by the relationship:

$$n_k = (s_k - s_{k-1}) / (\pi\, D_k) \qquad (10)$$

Substituting eq. 10 for n_k in eq. 9 gives:

$$s_{k+1} - s_k = s_k - s_{k-1} \qquad (11)$$

and thus:

$$s_{k+1} = 2s_k - s_{k-1} \qquad (12)$$

where subscript $k \geq 1$.

Considering that $s_0 = 0$ because panel P_0 is assumed to be the stationary end panel, from eq. 12 one obtains:

Panel P_{k+1}	Displacement s_{k+1}
P_2	$s_2=2s_1$
P_3	$s_3=2s_2-s_1=3s_1$
P_4	$s_4=2s_3-s_2=4s_1$

Thus, also with the arrangement of the third embodiment the desired kinematical link is obtained, i.e. the displacement of the k-th panel P_k is in any time k times the displacement of panel P_1 assuming that P_0 designates the end panel which is kept in a fixed position.